EFFECTIVENESS OF AMMONIUM ACETATE OR SODIUM DIACETATE AS A FEED ADDITIVE ON MILK PRODUCTION AND COMPOSITION BY DAIRY COWS

by

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INTRODUCTION

In the past several years, more dairymen have fed high levels of grain to cows to maximize milk production. As we push the cow harder with this practice, the physiological response is a reduction in milkfat percent, an important factor in determining the total price paid for milk. As the percent roughage:concentrate ratio decreases, milkfat falls accordingly. As this same ratio increases, milkfat percent rises but total milk production suffers. A high roughage ration may also lead to other complications, such as a negative energy balance in the high producing cow, possibly leading to ketosis. Thus, to optimize milk production without lowering milkfat percentages is a compromise of the roughage:concentrate ratio. To arrive at the optimum ratio of these two fractions, knowledge of why roughages and concentrates affect production differently is required.

In a high concentrate ration, the rumen volatile fatty acid (VFA) profile is typified by a low acetate plus butyrate to propionate ratio. Propionate is then used in the Kreb's Cycle in the eventual formation of milk

carbohydrates or is used in other cells as a source of cellular energy.

In a high roughage ration, the VFA profile produced is one showing a higher proportion of acetate + butyrate to propionate(4,7,9,10,20,21,26,27,29,51,52,53,54).

Conversely, the proportion of propionate to acetic plus butyrate increases in a high concentrate diet. However, acetate levels remain nearly constant.

This then is the basis for why milkfat levels are affected by the roughage:concentrate ratio, since the three blood precursors to milkfat are acetic acid, triglycerides, and beta-hydroxybutyric acid (16,55).

An argument can also be made concerning the efforts by many to change the pricing structure of milk to base wholesale prices on milk protein rather than milk fat. However, since the pricing structure is still based upon milk fat, and consumption of milkfat products is still strong (39), efforts should be made by milk producers to maximize milk fat percentages in their herds at a minimum expense to total milk production.

This study was conducted to determine if an exogenous source of acetic acid would have any effect upon heavily lactating dairy cows fed a high concentrate:roughage diet.

REVIEW OF LITERATURE

Acetic acid constitutes about 65% of the VFA production in the rumen, while propionate makes up about 20% of the total, butyrate about 10% and the remaining 5% is made up of isovaleric, valeric, and isobutyric acids as a molar ratio (2,13). As acetic and propionic acids leave the rumen, they remain unchanged. However, butyric acid is converted to beta-hydroxybutyric acid. Acetic, propionic, and beta-hydroxybutyric acids all pass through the liver where propionate is extracted from the blood for glucose production, while acetate and beta-hydroxybutyrate are transported to various tissues for energy production and fatty acid synthesis (3,8,12,37).

The metabolically active tissues of concern are the epithelial cells of the mammary gland. It is widely accepted that the cytoplasm of these cells is where fatty acid synthesis occurs. This fatty acid production is dependent upon the availability of the milk fat precursors (acetate and beta-hydroxybutyrate). The availability of these precursors is dependent upon the rate of blood flow to the mammary gland and upon the rate of mammary uptake. It is estimated that the ratio of blood flow to milk yield

is approximately 500 units of blood to supply enough milk precursors for one unit of milk, ranging from 1000:1 for cows in early lactation to as low as 400:1 for cows in later lactation (33,34).

Acetate and beta-hydroxybutyrate from blood supply all the carbon needed for fatty acid synthesis (44,46,47). beta-hydroxybutyrate is used primarily for the first four carbons of most fatty acids synthesized in the mammary gland, and the remainder is cleaved into two carbon units to be utilized as acetyl CoA for fatty acid synthesis (31,32,35). Acetate contributes to the C-4 up to C-14 fatty acids and part of the C-16 fatty acids (44,46,47).

The other source of fatty acids found in milk fat, triglycerides, are either consumed as part of the diet or are manufactured by bacteria in the rumen. It is estimated that , in ruminants, >50% of fatty acids in milk are derived from this source. Thus, a third of C-16 acids (palmitic) and nearly all of C-18 acids (stearic, oleic, and linoleic) come from this source (17).

Effects of acetate on milk production

Rook et al.(49) and Wilson et al.(57) gave ruminal infusions of acetic acid to lactating cows and showed an increase in both total milk and milkfat production.

Orskov et al.(43) infused both propionic acid and acetic acid into the rumen of lactating cows and found no difference in their respective utilizations.

Bickerstaffe et al.(5) determined that there was a positive correlation between mammary acetate uptake and milkfat production by using two different breeds of cattle. Uptake of acetate in Jerseys was 1.65 times higher than mammary acetate uptake in the Holsteins. Not coincidentally, milkfat in the Jerseys was 1.65 times higher than milkfat from the Holsteins.

Annison et al.(1) fed a high starch (concentrate):low roughage diet to four lactating cows and observed that milk fat percentage fell significantly in three cows and only slightly in another (Jersey cow). In the three cows where differences were observed, an increase in total rumen VFA concentration was also observed. While rumen propionate concentration doubled, rumen acetate concentrations remained constant. This occurrence is usually stated as a fall in the acetate:propionate ratio when, in actuality, it is an increase in the propionate to acetate ratio. There was also a significant decrease in blood concentrations of acetate and beta-hydroxybutyrate recorded in these affected cows. Absorption from the gastrointestinal tract is the major source of blood acetate(30).

The efficiency of exogenous acetate relating to energy usage was further addressed by Peters et al. (45). It was determined with Holstein cows, under normal physiological conditions, energy loss due to urinary excretions does not represent a meaningful energy loss.

Interactions of acetate with beta-hydroxybutyrate, glucose and buffers

The relationship between acetate, beta-hydroxybutyrate, and propionate must be understood to appreciate the contributions an exogenous source of acetate can make to milkfat production. As stated earlier, a ration typified by a high concentrate to roughage ratio produces a VFA profile with a high proportion of propionate to acetate and beta-hydroxybutyrate. Holter et al.(22), determined that ruminally infused acetate exerted a positive influence on both milkfat and energy content of the diet while propionate had a negative effect on these parameters.

The role of beta-hydroxybutyrate in relation to acetate and milkfat synthesis is not clearly understood. Forsberg et al.(14)determined that production of fatty acids, carbon dioxide, and citrate were increased in the absence of beta-hydroxybutyrate. This may indicate that beta-hydroxybutyrate might not be required to initiate

fatty acid synthesis in mammary tissue.

Glucose or glucose precursors also play a role in the conversion of acetate to milk fat. In a study by Orskov (42), utilization of energy for milk production was lower with high levels of acetate in the mammary gland accompanied by insufficient glucose or glucose precursors.

Rumen buffers, such as sodium bicarbonate, elevate acetate levels in the rumen. Hadjipanayiotou (19) elevated acetate levels and depressed propionate levels in the rumens of dairy goats with the feeding of sodium bicarbonate. However, roughage was found to be more efficient in elevating rumen pH, isovalerate, and acetate molar proportions.

Sources of acetate

Ammonium acetate

Ammonium acetate has the advantage of being a non-protein nitrogen source, as well as an acetate source. Salts of ammonia were nearly equal to urea and soybean meal as a source of protein for growing cattle and lambs but inferior to natural protein as a source of nitrogen for growing calves or finishing cattle (56).

Webb et al.(56) fed ammonium acetate in a liquid supplement to lactating cows. Response was favorable in

those cows fed the ammonium acetate treatment showing increased production and higher gains in body weight.

Jackson et al. (24) offered ammonium salts, of which ammonium acetate comprised 25% of the solution, to lactating cows in their drinking water. It was observed that there was a large variation in salt concentration tolerated without depressing water intake. The values ranged from 0.5%(w/w) to 8.0% (w/w).

Kay et al.(28) and Prescott et al.(48) fed ammonium acetate to lactating cows and heifers. They observed an appreciable increase in milkfat percentage. Prescott et al. also observed a slight increase in fat corrected milk yield.

Sodium diacetate

Sodium diacetate is a common mold inhibitor found in baked goods that has been used recently as a feed additive and forage preservative in the animal production industry. In the rumen, sodium diacetate combines with water yielding acetic acid. Acetate is absorbed into the bloodstream and is used as a milkfat precursor in the mammary gland , or is used by other cells as a source of energy(25).

Glabe et al.(15) used sodium diacetate as a mold inhibitor in ground poultry feed,whole kernel corn, and

corn silage. Mold spore levels were significantly lower in those samples treated with sodium diacetate than control samples.

Singh et al. (50) fed three levels of sodium diacetate (19.0, 37.5, and 112.5 g/kg diet) as an additive to the diet of day old broiler chicks. A control diet and an aureomycin diet were fed for comparison. Growth rate and efficiency of gain were nearly the same for all groups. The large and small intestines of a small percentage of the birds were examined for specific organisms. Lactobacillus counts in the ileum of the control group were 6.4×10^4 organisms/g of contents, while in the group fed the diet containing 112.5 g/kg of sodium diacetate Lactobcillus numbers increased to over 6.0×10^5. Streptococci numbered 2.0×10^6/g of contents for the control group, and in the same as above treatment group numbers dropped to 4.8×10^4/g of contents.

Draughon et al.(11) applied sodium diacetate to stillage at levels of 10 and 20 ppm to inhibit fungal growth. These treatments were shown to be not effective.

In an experiment conducted at the University of Wisconsin(25), lactating dairy cows were fed sodium diacetate in the grain mix at a level of .075%. An increase of .05 percentage points in milkfat was shown,

with total milk production demonstrating an upward trend (.77 kg/cow/day increase). It was observed that benefits derived from sodium diacetate occurred during early lactation, helping to offset a negative energy balance.

McCullough et al.(38) compared sodium acetate and sodium propionate as an additive to a total mixed ration consisting of corn silage and concentrate for lactating dairy cows. The cows fed the rations containing the sodium acetate showed a significant increase in total milk production and insignificant increases in milkfat and total solids.

Somatic Cell Count

Somatic cell count is the sum of the epithelic cells and leukocytes (white blood corpuscles) found in one milliliter of milk (36).

An infection in the udder (mastitis) is an invasion of the gland by various foreign bodies. When infection occurs, leukocyte numbers increase as a defense mechanism, destroying the foreign bodies by engulfing them, a phenomenom called phagocytosis (36).

Stress, such as heavy lactation, can also increase somatic cell counts. Heavy feeding of certain feedstuffs, such as cottonseed meal, has been associated with clinical

mastitis (40). Forages high in estrogen have also been implicated. Mostly inconclusive results from studies designed to determine the physiological mechanism of these problems have been observed. In one study, however, it was shown that estrogen had an inhibitory effect on the bacteriocidal properties of polymorphonuclear neutrophils (PMNs), a type of leukocyte that is the mammary gland's secondary defense against invading organisms. Resistance to mastitis by feeding a particular feed additive, mineral, or vitamin has not been shown (18).

Age of the animal has an impact on somatic cell count. Jaartsveld et al (23) determined from a study of 6215 lactating cows that as age increases, somatic cell count increases also, but more so in the presence of pathogens than in their absence. This observation was found at all production levels.

With cell counts of 500,000 or more, the probability of mastitis increases dramatically, while counts below this level show a sharply falling tendency (36).

EXPERIMENTAL PROCEDURES

Preliminary study

The objective of this study was to determine the highest degree of palatability among three concentrate mixtures using three different levels of ammonium acetate.

Ten cows in mid-lactation were randomly split into four groups, with three cows per treatment group and one control cow. Each group was fed a different level of ammonium acetate, arbitrarily designated due to the fact that no literature exists where ammonium acetate was fed as an additive to a dry concentrate mixture. Levels of 0.5%, 1.0%, and 2.0% of actual acetate from ammonium acetate (as a percentage of the concentrate) were used (Table 1).

Intake of alfalfa hay was held constant between groups,(11.4 kg/hd/day) while concentrate intake was maximized. The cows were stanchioned and released twice daily for milking in the parlor. Concentrate was offered twice daily, as was the alfalfa hay. The concentrate was offered as 3/16" pellets to eliminate any chance of sorting.

An adjustment period of three days was used for all three treatments to regain levels of intake observed prior to the study. Factors involved in this adjustment period included 1):Housing in stanchions versus being housed in freestalls prior to the study, 2): acclimating to a pelleted concentrate versus a rolled milo concentrate prior to the study, and 3): The definite "vinegar" odor observed in the treated feeds.

The cows were on treatment for a period of two weeks.

No statistical analyses were applied to this study due to the design, and because the nature of the study being a preliminary experiment.

Table 1. Composition of concentrate mixtures fed in the preliminary study.

		Rations		
Ingredient	Control	A	B	C
Rolled milo	83.8	85.2	86.6	90.2
Soybean meal	14.8	12.7	10.7	5.8
Ground limestone	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.5	0.5	0.5	0.5
Vitamin A&D premix	0.4	0.4	0.4	0.4
Ammonium acetate	0.0	0.6	1.3	2.6

A -- 0.5% acetate

B -- 1.0% acetate

C -- 2.0% acetate

Ammonium acetate = 114.8% CP

Experiment 1

A total of 18 lactating Holstein cows ranging from 1st to 7th lactations was used. A 3 X 3 Latin square design was used in which the cows were allotted to one of three treatments at freshening, and remained on each treatment for a period of four weeks (Table 2). The cows were switched to different treatments predetermined randomly at the time of freshening, constituting a total time frame for each cow of twelve weeks. Each four week period was used as a replication to enable comparisons between cows at similar points in their lactation curves. This procedure was used in an effort to equalize any differences that might be incurred with respect to individual lactation curves.

Cows were bunk fed grain according to appetite, and good quality alfalfa hay (Table 4) was offered at the rate of 50% of concentrate consumption. At no time were there more than 7 cows in one pen.

This experiment was carried out in the late spring and summer months, when temperatures were nearly always above the animal's thermal neutral zone.

Cows were milked twice daily with milk weights recorded in weigh jars. Milk samples were collected

weekly, on the day prior to lot change assignments. From these samples were determined milk fat, milk protein, somatic cell count, and total solids.

Milk fat and milk protein determinations were obtained by way of the Multispec M infrared milk analyser (Multispec, Multispec Limited Registered Office, Wheldrake, York, England). The basic operational principle of the Multispec M is that molecular vibrations of milk fat and milk protein absorb infrared radiation at distinctive wavelengths. Quantitative determinations of the milk fat and milk protein can then be obtained by measuring the level of absorption at these wavelengths. The Multispec M was calibrated weekly, daily, and hourly (each of these respective calibrations utilizes separate techniques).

Fat corrected milk was determined by using a weekly average of milk weights and the weekly milk fat analysis used in the equation: 4.0% FCM = (0.4 X milkweight) + (15 X fat weight).

Somatic cell counts were determined on a Fossmatic Electronic Somatic Cell Counter (A/S N. Foss Electric, Denmark).

Total solids were determined by use of a lactometer for specific gravity readings and a conversion chart and formula, which took into account temperature and milk fat

differences.

The composition of concentrates used are in table 3. These concentrates were formulated to meet NRC requirements(39), assuming that the alfalfa hay provided 33% of ration dry matter. Sodium bentonite, whey, and urea were added as needed to balance for those ingredients present in Crop Cure, the source of sodium diacetate.

Body weights were taken weekly, on the day prior to lot change assignments.

Lots were cleaned daily, and freestalls were provided with sand bedding.

This experiment was designed to let each cow be her own control. A statistical analysis of variance (6) was applied to each variable which included: milk fat, milk production, milk protein, total solids, somatic cell count, and body weights.

Table 2. Experimental design of cow allottment in experiment 1.

		1	2	3*
1	523	2	1	3
2	598	1	3	2
3	1109	3	2	1
4	622	3	1	2
5	1089	1	2	3
6	1049	2	3	1
7	1097	1	3	2
8	981	2	3	1
9	1085	3	2	1
10	1106	2	1	3
11	763	3	1	2
12	1012	1	2	3
13	967	3	2	1
14	1004	2	3	1
15	626	1	3	2
16	503	1	2	3
17	577	3	1	2
18	452	2	1	3

* Numbers in replications represent ammonium acetate (1), control (2), and sodium diacetate (3).

Table 3. Composition of concentrate mixture fed to control and treated animals in experiment 1.

	Rations		
Ingredient	Control	Sodium diacetate	Ammonium acetate
	--------------- % ---------------		
Rolled corn	71.98	70.78	71.40
Soybean meal	22.10	22.10	22.10
Sodium bicarbonate	1.50	1.50	1.50
Dicalcium phosphate	1.20	1.20	1.20
Ground limestone	0.60	0.60	0.60
Magnesium oxide	0.50	0.50	0.50
Trace mineral salt	0.50	0.50	0.50
Vitamin A & D premix	0.40	0.40	0.40
Urea	0.42	0.42	0.00
Sodium bentonite	0.70	0.00	0.70
Whey	0.10	0.00	0.10
Ammonium acetate	0.00	0.00	1.00
Crop Cure**	0.00	2.00	0.00

**Crop Cure consists of: Sodium diacetate 50%, sodium bentonite 35%, white salt 10%, and whey 5%.

Table 4. Composite analysis of alfalfa hay fed to cows in experiment 1.

	%
Dry matter	91.1
Crude protein	20.8
Acid detergent fiber	29.0

RESULTS AND DISCUSSION

Preliminary study

Intake of pelleted concentrate was determined to be constant for the treatments with levels of 0.5% and 1.0% actual acetate from ammonium acetate (Table 5). Intake for those cows on the 2.0% level of treatment showed a decrease in consumption of approximately 1.24 kg/hd/day.

Upon analysis of the three concentrates, it was discovered that a portion of the acetate and nearly all of the ammonia fraction were volatilized during the heating process of pelleting (Table 6). Results were arrived at through gas chromatography and Conway procedures. Since the concentrates in experiment 2 would not be pelleted, it was expected that actual levels of acetate would be more precise. Since acetate levels of 0.72% and 1.32% were near the palatability threshold, 1.0% acetate was chosen as the level of treatment for experiment 1.

Table 4. Average daily intake of concentrate for cows in preliminary study.

Treatment	kg/hd/day
Control	7.27
0.5% actual acetate	7.50
1.0% actual acetate	7.36
2.0% actual acetate	6.14

Table 5. Percentage acetate and ammonia levels in concentrate mixture used in preliminary study following pelleting.

Level of acetate mixed in feed	Actual levels of acetate
0.5%	0.458%
1.0%	0.720%
2.0%	1.320%

Experiment 1

A summary of parameters tested and concentrate intake data is found in Table 7, probability values in Table 8, analysis of concentrates fed in Table 9, and individual cow data in appendix Table 1. Milk production, milk protein, total solids, and body weights were not significantly affected for the entire 12 week period (Table 8). The only criterion significantly affected were the somatic cell counts for both treatment groups and milk fat in the group fed the sodium diacetate. However, a trend toward increased milkfat occurred in the cows fed ammonium acetate.

<u>Fat corrected milk production</u>

While fat corrected milk production was not significantly affected for the entire experimental period (P=.53), a trend for increased production was shown in replications one and two for those cows fed the sodium diacetate and ammonium acetate (Table 7).

During replication one (Table 7), cows receiving sodium diacetate and ammonium acetate gave 28.63 and 29.73 kg/day, respectively compared to 25.49 kg/day for control animals. Concentrate intakes for this replication were 17.1 kg/day for control cows, 14.9 kg/day for cows

receiving sodium diacetate, and 19.3 kg/day for cows fed ammonium acetate. Control cows gave 26.40 kg/day during replication two, while the sodium diacetate group averaged 28.85 kg/day and the ammonium acetate group 30.19 kg/day. Concentrate intake for replication two was 16.3 kg/day, 15.7 kg/day, and 16.7 kg/day, resectively. The means reversed during replication three when the control group averaged 28.50 kg/day and the sodium diacetate cows dropped to 25.94 kg/day, while milk production in the ammonium acetate group gave the least amount of any replication observed, averaging 24.66 kg/day. Intake of concentrates for replication three were 16.4 kg/day for control cows, 16.9 kg/day for cows fed sodium diacetate, and 16.6 kg/day for cows fed ammonium acetate. Averaging the three replications shows an increase of 1.26 kg for the sodium diacetate and only 0.69 kg when animals were fed ammonium acetate (Table 7).

Johnston and Erickson (25) found a significant increase in milk production (0.77 kg/day) which is only 61% of the overall increases observed in our treatments. However, we used 18 cows in a 3 X 3 Latin square design whereas the Wisconsin workers used 50 cows and fed 0.075% sodium diacetate in their concentrate. Prescott et al. (48) observed a slight increase in fat corrected milk using

ammonium acetate. Webb et al. (56) found a significant increase in milk production of 1.27 kg/day (P<.01) and an increase of fat corected milk production of .98 kg day (P<.05)with cows fed ammonium acetate. Webb used a switch-back design with three two week comparison periods. Their results were somewhat similar to the present experiment in that the first two replications favored ammonium acetate whereas the results in the third replication were equivocal.

These results indicate a more efficient usage of acetate in the first eight weeks of lactation, although they were not statistically significant.

Milk fat production

Milk fat percentages for all three treatment groups during the first replication were nearly equal (Table 7), with 3.19% for the control cows, 3.15% milk fat for the sodium diacetate group, and 3.25% for the ammonium acetate fed cows. During replication two, cows fed the sodium diacetate were significantly higher (P=.02) in milkfat percentage than the other groups (3.07% versus 2.86% for the ammonium acetate group and 2.75% for the control

cows)(Table 8). However, cows fed the ammonium acetate were still higher in milkfat percentage than the control group. Results from replication two were nearly equal to those observed in replication three.The cows fed the sodium diacetate averaged 2.99% milk fat, while the ammonium acetate group averaged 2.89% and the control cows averaged 2.77%. Averaging the three replications shows an increase of 0.19% milkfat for the cows fed sodium diacetate and 0.12% increased milk fat for the ammonium acetate cows.

Johnson et al.(25) showed an increase of 0.05% in milk fat when cows were fed sodium diacetate at a rate of 0.075% of the concentrate. Webb et al.(56) observed that milk fat percentage was not affected by supplementation of ammonium acetate.

Milk protein production

A trend toward slightly higher milk protein percentage in the third replication (Table 7) was shown in those cows fed the ammonium acetate (2.99% milk protein versus 2.89% for the sodium diacetate group and 2.85% for the control group). The control group cows showed a decline in milk protein percent through each replication, while each treatment group showed an increase or a stabilization in

milk protein (Table 8). However, results were not significant (P=.57)

When averaging all replications, the cows on the control ration showed a higher percent of milk protein than the group fed the sodium diacetate (+0.03%) and the group fed ammonium acetate (+0.06%)

Total solids

No trends were shown (Table 7) for total solids production (P=.57), (Table 8). Overall, the group fed sodium diacetate produced 0.03 percentage points more than the ammonium acetate group and 0.07 more than the control group.

Somatic cell count

A significant trend for lower somatic cell count (P=.03) was shown for those cows fed both sodium diacetate and ammonium acetate (Table 7). In replication one, somatic

cell counts were over three times higher for the control group (460 X 10^3) compared to either treatment group (140 X 10^3 for the sodium diacetate group and 129 X 10^3 for the ammonium acetate group). A leveling off of cell counts occurred in replications two and three (Table 7). Overall means indicate a significantly higher somatic cell count for the cows fed the control ration (242 X 10^3) compared to either the sodium diacetate group (150 X 10^3) or the ammonium acetate group (130 X 10^3).

From these observation, conclusions can be made that perhaps helping to offset a negative energy balance early in the lactation can promote a healthier mammary gland and lead to lower somatic cell counts.

Further research to determine the cause of lower somatic cell counts due to feeding exogenous acetate is needed.

Body weight

No trends for either increase or decrease of body weight by any treatment (Table 8) were shown (P=.83), either within replications or in the overall means, which were nearly equal (565.43 kg for the control group, 567.3

kg for the sodium diacetate group and 568.3 kg for the ammonium acetate group).

<u>Concentrate intake</u>

Average concentrate intake information for experiment one can be found in table 7. The cows fed sodium diacetate averaged less intake than both the control group and the group fed ammonium acetate. Fat corrected milk production and milk fat percentage was highest for the cows fed sodium diacetate as compared to any other group. This information indicates that the cows fed sodium diacetate were more efficient in milk production and milk fat production.

No trends associating concentrate intake with other parameters could be discerned.

Table 7. Least square means and standard deviation for parameters measured in Experiment 1 and average daily intake of concentrates fed in Experiment 1.

Parameter	Rep	Control	TREATMENT sodium diacetate	ammonium acetate
Fat	1	25.49±8.23	28.63±6.95	29.73±8.93
corrected	2	26.40±4.35	28.85±6.82	30.19±6.93
milk (kg)	3	28.50±5.38	25.94±7.83	24.66±3.17
	overall	27.02 (.65)	28.28 (.68)	27.71 (.60)
Milk fat	1	3.19±.42	3.15±.33	3.25±.58
percentage	2	2.75±.37	3.07±.27	2.86±.26
	3	2.77±.36	2.99±.23	2.89±.48
	overall	2.87 (.05)	3.06 (.06)	2.99 (.05)
Milk	1	3.23±.30	3.14±.30	3.03±.20
protein	2	2.95±.08	2.89±.22	2.82±.15
percentage	3	2.85±.18	2.89±.18	2.99±.19
	overall	3.01 (.04)	2.98 (.04)	2.95 (.04)
Total	1	8.65±.49	8.49±.29	8.52±.29
solids	2	8.28±.22	8.57±.38	8.40±.24
percentage	3	8.42±.29	8.48±.34	8.55±.17
	overall	8.44 (.04)	8.51 (.04)	8.48 (.04)
Somatic	1	459.5±326.7	139.8±66.7	129.2±44.6
cell count	2	111.6± 55.3	82.4±15.5	135.6±81.3
(thous.)	3	169.1±174.2	198.5±99.2	134.3±68.9
	overall	241.7 (30.3)	149.6 (31.6)	129.5 (28.1)
Body	1	573.3±58.4	547.5± 67.5	570.6±114.1
weight	2	536.6±40.9	562.4±102.6	599.1± 39.8
(kg)	3	581.4±93.8	585.1± 35.5	554.4± 59.3
	overall	565.4 (3.5)	567.3 (3.6)	568.3 (3.2)
Concentrate	1	17.1	14.9	19.3
intake	2	16.3	15.7	16.7
(kg/hd/day)	3	16.4	16.9	16.6
	overall	16.6	15.8	17.6

( )= Standard error of least square means

Table 8. P values between treatments.*

Treatment	Parameter	Control	Sodium diacetate	Ammonium acetate
	fat corrected milk			
Control		x	0.19	0.44
Sodium diacetate		0.19	x	0.53
Ammonium acetate		0.44	0.53	x
	milk fat			
Control		x	0.02	0.12
Sodium diacetate		0.02	x	0.34
Ammonium acetate		0.12	0.34	x
	milk protein			
Control		x	0.62	0.29
Sodium diacetate		0.62	x	0.60
Ammonium acetate		0.29	0.60	x
	total solids			
Control		x	0.29	0.54
Sodium diacetate		0.29	x	0.61
Ammonium acetate		0.54	0.61	x
	somatic cell count			
Control		x	0.04	0.01
Sodium diacetate		0.04	x	0.64
Ammonium acetate		0.01	0.64	x
	body weight			
Control		x	0.70	0.54
Sodium diacetate		0.70	x	0.84
Ammonium acetate		0.54	0.84	x

* Responses are comparisons between each treatment group individually represented by a P value. Where comparisons cannot be made, x is the response.

Table 9. Analyses of concentrates fed to cows in Experiment 1.

	Treatment		
Component	Control	Sodium diacetate	Ammonium acetate
	% (DMB)		
Dry matter	88.7	89.0	88.9
Crude protein	18.89	18.54	18.76
NEl mcal/kg	35.36	35.67	35.50
Calcium	0.84	0.81	0.83
Phosphorus	0.72	0.69	0.70

CONCLUSIONS

The evidence suggests that sodium diacetate was more useful in elevating milk fat percentages than ammonium acetate. Since both treatment groups at least tended toward increased milkfat, this suggests that exogenous acetate, in either form, may be useful.

Fat corrected milk production, milk protein percentages, total solids, and body weights were not affected by either treatment group.

Cows fed sodium diacetate were more efficient at converting feedstuffs to milk and milk fat.

The significant decrease in somatic cell counts for the treatment groups is difficult to interpret. Further research aimed specifically at somatic cell count response by cows fed exogenous acetate is needed.

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VITA

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APPENDIX

Table 1. Weekly data gathered from experiment 2.

wk = week on experiment
FCM = fat corrected milk (kg/day)
MF = milk fat (%)
prot = milk protein (%)
TS = total solids (%)
SCC = somatic cell count (thousands/ml)
BW = body weight (kg)
trt = treatment (C = control, A = ammonium acetate, N = sodium diacetate)

Cow # 523

wk	FCM	MF	prot	TS	SCC	BW	trt
1	29.5	3.18	3.06	8.34	915	614.7	C
2	33.6	3.12	3.09	8.40	468	622.4	C
3	39.3	3.28	2.91	8.61	387	622.0	C
4	39.6	2.96	2.86	8.62	242	612.9	C
5	41.0	3.10	2.70	8.50	273	613.8	A
6	38.8	3.11	2.65	8.32	333	606.5	A
7	39.3	3.00	2.68	8.20	229	608.4	A
8	36.9	2.86	2.74	8.35	163	616.5	A
9	38.2	2.98	2.74	8.55	333	612.9	N
10	35.1	3.02	2.60	8.23	538	624.7	N
11	36.7	3.03	2.81	8.43	480	613.8	N
12	35.5	3.09	2.71	8.33	31	599.3	N

cow # 598

wk	FCM	MF	prot	TS	SCC	BW	trt
1	32.8	4.01	3.24	8.98	113	772.7	A
2	38.6	3.61	3.42	9.05	128	768.2	A
3	46.1	3.79	2.85	8.58	305	730.9	A
4	37.0	2.46	2.95	8.89	57	750.0	A
5	37.2	2.30	2.90	8.84	43	745.5	N
6	38.4	2.86	2.94	8.70	29	739.1	N
7	39.6	3.20	2.99	8.64	47	743.7	N
8	36.6	3.11	3.10	8.80	45	720.9	N
9	37.8	2.98	3.16	9.02	40	719.1	C
10	36.3	3.52	2.95	8.43	49	730.9	C
11	34.9	2.97	3.22	8.82	103	724.6	C
12	32.5	2.84	3.29	9.09	57	707.3	C

cow # 1109

wk	FCM	MF	prot	TS	SCC	BW	trt
1	17.1	3.48	3.13	8.32	252	468.5	N
2	19.1	3.28	3.01	8.06	256	469.9	N
3	21.6	2.64	3.02	8.08	330	481.2	N
4	23.9	2.89	2.80	8.13	127	498.0	N
5	20.8	2.70	3.10	8.19	157	503.0	C
6	20.5	2.41	3.02	8.26	52	507.6	C
7	21.9	2.54	3.13	8.11	104	517.6	C
8	22.8	2.66	2.95	8.31	85	516.7	C
9	23.7	2.89	3.06	8.45	84	535.7	A
10	22.5	2.58	3.02	8.41	73	535.7	A
11	22.7	2.93	3.04	8.39	165	508.5	A
12	22.6	3.08	2.98	8.19	67	519.4	A

cow # 622

1	30.3	3.32	3.08	8.31	242	543.9	N
2	31.7	2.74	2.89	8.10	160	547.5	N
3	33.5	2.71	2.64	7.97	403	558.4	N
4	32.6	2.64	2.55	8.15	86	541.2	N
5	38.2	3.60	2.60	8.10	60	557.5	A
6	31.2	2.35	2.58	7.90	33	532.1	A
7	31.8	3.09	2.53	7.92	126	532.1	A
8	28.8	2.54	2.63	8.03	49	560.2	A
9	31.4	2.89	2.56	7.85	40	538.4	C
10	30.5	2.72	2.63	NA	127	562.1	C
11	28.5	2.24	2.64	7.95	66	544.8	C
12	30.9	2.60	2.71	8.05	53	564.8	C

cow # 1089

1	17.3	2.45	3.36	8.22	197	526.6	A
2	20.0	2.55	3.01	7.96	306	527.5	A
3	18.6	2.13	2.89	8.23	129	529.8	A
4	18.7	2.25	2.91	7.95	100	510.3	A
5	23.4	2.23	2.91	8.07	107	543.9	C
6	23.3	2.31	2.88	8.06	131	560.2	C
7	25.5	2.86	2.77	7.97	129	565.7	C
8	25.3	2.73	2.86	8.22	105	557.5	C
9	22.3	2.40	2.80	NA	107	584.8	N
10	16.1	2.56	2.65	7.93	337	503.0	N
11	19.1	3.31	2.85	7.91	38	536.6	N
12	20.0	2.82	2.84	8.26	179	527.5	N

cow # 1049

wk	FCM	MF	prot	TS	SCC	BW	trt
1	15.8	4.00	3.74	8.99	199	518.5	C
2	18.1	3.63	3.46	9.15	139	531.2	C
3	16.6	2.13	3.52	9.53	80	531.6	C
4	20.4	3.09	3.40	9.24	75	524.8	C
5	21.3	2.84	3.30	9.05	61	541.2	N
6	22.2	3.24	3.30	9.15	92	552.1	N
7	23.0	3.38	3.22	9.30	120	565.7	N
8	21.5	3.38	3.27	9.28	93	563.0	N
9	21.2	3.79	3.30	8.43	213	575.7	A
10	20.4	3.14	3.33	8.43	121	563.9	A
11	22.2	3.56	3.33	8.93	68	565.7	A
12	18.7	3.15	3.24	9.16	136	563.9	A

cow # 1097

1	18.2	2.86	2.91	8.22	143	408.6	A
2	18.1	2.18	2.63	8.06	211	405.0	A
3	18.5	2.35	2.36	7.92	81	397.3	A
4	18.8	2.30	2.44	7.99	145	395.0	A
5	20.3	2.53	2.67	8.28	35	416.8	N
6	21.5	2.64	2.63	8.03	59	424.0	N
7	21.0	2.88	2.62	8.45	50	427.7	N
8	24.7	3.70	3.23	8.67	117	431.3	N
9	23.7	3.70	2.63	8.32	128	445.8	C
10	21.0	2.85	2.80	8.42	114	428.6	C
11	19.5	2.25	2.87	8.30	62	437.7	C
12	18.8	2.12	2.69	8.25	50	435.8	C

cow # 981

1	26.7	3.02	3.28	9.20	289	566.6	C
2	28.1	3.35	3.17	9.17	64	580.2	C
3	27.7	3.49	2.97	8.85	83	548.4	C
4	29.0	3.45	2.97	8.99	83	543.0	C
5	25.4	3.33	3.04	8.69	47	555.7	N
6	28.0	3.63	3.00	8.83	66	556.6	N
7	26.5	3.84	3.01	8.72	64	576.6	N
8	25.2	3.34	3.13	8.89	56	570.2	N
9	24.4	3.30	2.85	8.34	127	575.7	A
10	23.8	3.52	3.14	8.60	97	591.1	A
11	23.1	3.41	3.16	8.90	85	570.2	A
12	22.6	3.40	3.17	9.01	79	570.2	A

cow # 1085

wk	FCM	MF	prot	TS	SCC	BW	trt
1	23.4	4.14	3.07	8.38	103	439.5	N
2	24.6	3.56	3.19	8.46	93	448.6	N
3	25.4	2.99	2.76	8.37	87	440.4	N
4	21.3	2.02	2.95	7.95	118	442.7	N
5	19.2	2.43	2.60	7.99	133	467.6	C
6	26.0	3.24	2.93	8.60	70	482.1	C
7	26.7	3.19	3.00	8.51	46	474.9	C
8	23.2	2.54	2.93	8.11	103	483.1	C
9	25.4	3.24	2.97	8.40	113	478.5	A
10	19.5	2.21	3.05	8.55	133	484.0	A
11	23.7	3.37	3.00	8.47	105	476.7	A
12	20.3	2.60	2.97	NA	58	474.0	A

cow # 1106

1	13.5	2.22	3.38	7.99	1130	545.7	C
2	17.9	3.25	3.12	8.23	205	575.7	C
3	14.5	2.40	3.00	8.28	182	555.7	C
4	14.6	2.36	2.98	8.30	131	568.4	C
5	19.2	2.63	3.02	8.03	134	603.8	A
6	20.5	2.57	3.03	8.66	75	595.6	A
7	21.7	3.00	3.03	8.88	99	624.7	A
8	22.6	2.98	3.08	8.70	125	621.1	A
9	21.4	3.07	3.02	8.71	179	611.1	N
10	19.6	2.77	2.96	8.81	102	617.4	N
11	20.9	2.91	2.95	8.86	122	601.1	N
12	20.2	2.67	2.89	NA	114	619.3	N

cow # 763

1	33.7	4.47	3.27	8.77	96	669.2	N
2	35.5	3.11	2.98	8.87	117	657.4	N
3	31.2	2.16	2.93	8.68	135	640.1	N
4	29.6	2.46	2.77	8.39	94	628.3	N
5	30.9	2.21	2.74	8.04	31	630.2	A
6	27.6	2.88	2.60	8.33	56	617.4	A
7	32.5	2.85	2.80	8.55	49	630.2	A
8	31.2	2.78	2.85	NA	90	637.4	A
9	29.2	2.58	2.76	8.37	116	637.4	C
10	28.3	2.32	2.77	8.62	36	633.8	C
11	22.1	1.81	2.83	8.29	68	625.6	C
12	19.8	1.91	2.88	NA	95	622.9	C

cow # 1012

wk	FCM	MF	prot	TS	SCC	BW	trt
1	29.2	3.81	3.41	9.01	219	591.1	A
2	30.5	2.91	3.10	8.76	55	585.7	A
3	40.2	4.32	3.17	8.81	42	562.1	A
4	37.1	3.75	3.01	8.65	79	561.1	A
5	32.8	3.08	3.17	8.42	48	570.2	C
6	31.7	3.31	3.06	8.59	59	580.2	C
7	32.9	3.51	3.05	8.80	69	588.4	C
8	30.2	3.42	3.10	8.63	121	595.6	C
9	29.6	3.48	3.21	8.75	146	573.9	N
10	26.9	3.17	3.13	8.60	147	578.4	N
11	27.7	3.25	3.15	8.73	154	579.3	N
12	25.6	3.24	2.95	NA	169	578.4	N

cow # 967

1	33.1	2.80	2.90	8.71	53	586.6	N
2	29.2	2.18	2.96	8.26	64	562.1	N
3	28.2	2.21	2.77	8.24	117	560.2	N
4	30.7	2.69	2.87	8.31	50	560.2	N
5	31.9	2.88	2.88	7.85	80	565.7	C
6	26.5	2.11	2.88	NA	31	575.7	C
7	28.2	2.49	2.93	8.45	59	547.5	C
8	28.3	2.33	2.92	8.10	57	562.1	C
9	25.6	2.10	2.84	8.62	53	548.4	A
10	23.8	2.20	2.70	NA	93	552.1	A
11	21.1	1.52	2.82	8.23	66	564.3	A
12	25.4	2.40	2.90	8.56	50	NA	A

cow # 1004

1	33.2	3.20	2.70	8.59	45	510.3	C
2	29.4	2.40	2.67	8.18	48	500.3	C
3	31.5	2.73	2.63	6.15	51	513.0	C
4	30.5	2.79	2.59	8.31	107	507.6	C
5	30.8	2.92	2.68	8.48	28	514.8	N
6	28.6	3.02	2.71	8.18	100	538.4	N
7	29.2	2.87	2.70	8.46	163	492.1	N
8	27.4	2.95	2.64	8.07	129	506.7	N
9	27.4	3.03	2.73	8.46	74	490.3	A
10	26.2	3.00	2.70	NA	108	488.5	A
11	25.4	2.86	2.67	8.32	267	487.1	A
12	26.1	3.10	2.80	8.46	55	NA	A

cow # 626

wk	FCM	MF	prot	TS	SCC	BW	trt
1	33.8	2.53	2.82	8.36	66	604.7	A
2	35.8	2.45	2.84	8.19	96	608.4	A
3	40.6	3.17	2.81	NA	60	594.7	A
4	40.3	3.18	2.75	8.36	47	610.2	A
5	36.2	3.20	2.76	NA	100	612.9	N
6	36.7	2.93	2.79	8.01	140	593.8	N
7	30.7	2.33	2.78	8.39	53	588.4	N
8	33.7	2.80	2.71	8.26	62	568.4	N
9	30.7	2.56	2.85	8.44	303	589.3	C
10	32.3	2.90	2.90	8.53	83	588.4	C
11	33.6	3.27	2.87	8.58	441	592.0	C
12	35.5	3.34	2.90	NA	122	590.2	C

cow # 503

1	27.6	3.20	3.10	7.54	147	563.9	A
2	31.8	3.36	3.21	8.97	77	553.0	A
3	34.5	3.82	2.99	8.61	75	557.5	A
4	NA	NA	NA	NA	NA	561.1	A
5	27.5	2.68	3.04	8.56	182	556.6	C
6	29.9	3.14	2.92	8.34	274	542.1	C
7	27.7	2.81	2.80	8.29	172	526.6	C
8	25.4	2.83	2.80	NA	176	548.4	C
9	26.0	3.36	2.87	8.50	523	552.1	N
10	29.4	3.60	2.90	8.55	381	557.5	N
11	25.5	2.77	2.80	8.30	581	563.9	N
12	26.7	2.73	3.10	NA	547	563.0	N

cow # 577

1	39.4	2.91	2.79	8.38	70	588.4	N
2	43.0	3.06	3.79	8.29	55	579.3	N
3	42.8	2.96	2.81	8.12	68	589.3	N
4	38.0	3.13	2.70	8.29	120	600.2	N
5	37.5	2.67	2.86	8.23	111	583.8	A
6	31.3	2.15	2.71	8.23	35	565.7	A
7	33.4	2.43	2.72	8.41	58	582.9	A
8	29.6	2.56	2.78	NA	79	593.8	A
9	25.9	2.30	2.64	8.29	255	565.7	C
10	27.8	2.20	2.90	8.64	104	572.0	C
11	29.3	2.41	2.88	8.48	209	579.3	C
12	30.6	2.54	3.00	NA	151	594.7	C

cow # 452

wk	FCM	MF	prot	TS	SCC	BW	trt
1	34.5	3.64	3.08	NA	121	676.5	C
2	33.3	3.22	3.04	8.47	56	584.8	C
3	36.9	3.51	3.12	9.13	87	668.3	C
4	37.5	2.32	2.99	NA	213	682.8	C
5	32.5	3.52	3.03	8.78	184	669.2	A
6	35.6	3.38	2.99	8.60	123	661.0	A
7	27.1	2.36	3.07	8.80	85	663.7	A
8	29.6	2.56	2.78	NA	79	660.8	A
9	29.4	3.22	2.92	8.69	591	659.2	N
10	30.7	3.40	3.10	8.76	148	663.7	N
11	30.1	2.96	3.07	8.57	148	667.4	N
12	28.8	2.90	3.10	NA	240	672.8	N

EFFECTIVENESS OF AMMONIUM ACETATE OR SODIUM DIACETATE AS A FEED ADDITIVE ON MILK PRODUCTION AND COMPOSITION BY LACTATING DAIRY COWS

by

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AN ABSTRACT OF A MASTER'S THESIS

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Since milkfat is the basis of the pricing structure for milk, increasing milkfat production would mean increased dollars for the dairyman, if this increase is cost effective. This research was undertaken to determine if an exogenous source of acetic acid fed as part of the ration would effect milk production or milk composition of heavily lactating cows fed a high concentrate:low roughage diet. In experiment one, levels of 0.5, 1.0, and 2.0% acetate (as ammonium acetate) were fed as part of the concentrate to determine the most palatable level. The concentrates were pelleted to eliminate sorting. During the pelleting process, a portion of the acetate was volatilized and lost as a gas. However, it could be determined that a level of 1.0% acetate was the most effective level. In experiment two, 18 fresh cows and heifers were in a 3 x 3 Latin square experiment with six replications and random allottment within the square to study the effects of feeding 1.0% actual acetate as ammonium acetate or sodium diacetate. Parameters measured were weekly production of fat corrected milk , milk fat , milk protein , total solids , somatic cell count, and body weight.

A trend for increased production of fat corrected milk was shown for the ammonium acetate and sodium diacetate treated groups in the first eight weeks after parturition,

and for increased milkfat production was shown in these same groups (P=.06) in the last eight weeks of the experiment. Milk protein production, total solids production, and body weights were not affected by either the ammonium acetate or sodium diacetate. Concentrate intake data indicates that cows fed sodium diacetate were more efficient at converting feed to milk. Somatic cell count was lowered significantly by feeding of either ammonium acetate (P=.01) or sodium diacetate (P=.04). Considering these observations, further research on effects of exogenous acetate on somatic cell counts is needed.